SKILL RETENTION AND ITS IMPLICATIONS
FOR NAVY TASKS: AN ANALYTICAL REVIEW

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Richard E. Hurlock
William E. Montague

Reviewed by
John D. Ford, Jr.

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A review of relevant research literature was conducted to identify probable variables contributing to skill loss in the Navy. Findings were grouped into five categories--personnel characteristics, task variables, training factors, job conditions, and retraining factors. One of the most important causes of skill deterioration is nonuse. This can occur when there are infrequent opportunities to practice or perform a skill or when feedback is absent or inadequate. The most important retention variable is the amount of

learning acquired before nonuse. This learning is influenced by ability level, task complexity, quality of practice, and feedback conditions. In addition to these variables and the recall conditions, skill deterioration is controlled by the length of the nonutilization period. Retraining can be quickly achieved by a variety of methods; it is affected by the same variables as initial learning. Difficulties of identifying and evaluating skill losses in the Navy, and indirect methods for assessing or predicting skill deterioration, were discussed.

FOREWORD

This research and development was conducted in support of exploratory development work unit ZF63-522-001-010-03.07 (Skill and Knowledge Retention) under the sponsorship of the Chief of Naval Operations (OP-01). The objective of this work unit is to develop techniques that can be used to design training and to structure job conditions to minimize performance deterioration due to forgetting. This is the first report on this work. It reviews and summarizes the relevant literature on skill loss as it relates to conditions in the Navy. The findings can be used to help identify and understand the personnel, task, training, and job conditions that influence skill deterioration. The next phase of this effort will be to develop procedures for predicting skill loss problems in Navy jobs. It is anticipated that this information can then be used for making recommendations to improve skill retention.

This report is intended for use by managers and developers of Navy training programs and by personnel in the defense training research and development community.

JAMES F. KELLY, JR.
Commanding Officer

JAMES J. REGAN
Technical Director

SUMMARY

Problem

Recent concern about fleet readiness has made the maintenance of personnel skills an important issue. Quantitative methods of assessing performance are needed to document specific skill losses. The necessary techniques are not generally available, however, and they cannot be developed and implemented except at great cost. Thus, there is a need to develop alternative methods of identifying existing or potential skill loss problems.

Objective

The objective of this work was to provide background information needed to help understand and identify conditions that cause skill losses.

Approach

The recent research literature relevant to skill deterioration was reviewed. Variables reported to be most closely related to skill loss were identified and discussed in reference to Navy personnel management practices.

Findings and Discussion

The factors affecting the retention of skill were grouped into five categories: personnel characteristics, task variables, training factors, job conditions, and retraining factors. The most important retention variables were those associated with ability level, type of task, amount of learning, quantity of practice, quality of feedback, the learning environment, length of nonutilization, and recall conditions. Some of the findings were:

1. Skill retention depends primarily upon the amount of initial training.

2. Regular practice of skills is required to prevent their deterioration.

3. With practice, the performance level of some skills continues to improve over a long period of time.

4. Knowledge of results (corrective feedback) is needed for eliminating errors and for maintaining and improving skills.

5. The most important tasks in the Navy tend to be procedural in nature, and complex procedural tasks are the most difficult to learn and the most easily forgotten.

6. As the number of steps and subtasks of a job increases, forgetting becomes more likely.

7. Overlearning can help to reduce memory load in complex tasks and to improve retention.

8. Ability levels influence the speed of learning.

9. Skill deterioration is primarily a function of the length of nonutilization.

10. Environmental, contextual, physiological, and psychological conditions during recall can be detrimental.

11.   Retraining and initial training function similarly, and retraining can be achieved quickly by a variety of methods.

Within the primary variables of amount of learning and length of nonutilization, practice is a key factor in the retention of skills. The quality of the practice is a function of the number of opportunities to perform the key parts of a task and the diagnostic quality of the feedback. Duty and watch assignments do not always provide personnel with useful practice. This is because inadequate feedback and infrequent opportunities to perform critical steps are subtle causes of skill loss.

Conclusions

Research findings based on simple tasks and artificially manipulated conditions are straightforward and easy to understand, but they are not always easy to apply to Navy tasks.

The primary factors associated with skill retention are the amount of learning prior to a period of nonutilization and the length of the nonutilization period. Previous experience, ability level, the type of skill in question, the quantity of practice, and the quality of feedback also influence learning and retention.

Unfortunately, Navy jobs are seldom learned during a single, clean-cut time period, and subsequent training and experience on the job are difficult to ascertain, thus complicating the assessment of skill retention. Some parts of an individual's job skills will be contributed by past knowledge and experience; the rest will be derived from formal school training, from on-the-job training, and from continuing work experience.

The experimental literature indicated that skill deterioration is determined largely by the length of the period of nonuse. Again, job conditions in the Navy seldom involve a single period of nonutilization that dominates the degree of forgetting. Each interval between opportunities to learn, practice, or perform a skill is a period of nonutilization, and each instance of performance is a recall condition that may provide practice or reveal skill deterioration.   Distinguishing between practice and nonpractice is sometimes difficult or impossible without additional analytic information.   When personnel are standing watches and performing routine work, they may not be practicing the critical skills they need for their ratings. This happens because critical events seldom occur frequently enough during routine watch and work periods to maintain high skill levels.

Recommendation

Since performance evaluation tests are not generally available for quantitatively identifying specific deficiencies on an individual basis, skill deterioration may go undetected in the Navy. Cost, development, validation, and implementation problems all serve to prevent the use of performance evaluation tests. An indirect method using descriptive procedures to obtain information about factors associated with skill loss and to help predict existing or potential skill loss problems is therefore recommended. It is anticipated that the resulting information can serve as a basis for suggesting management actions to remedy the problem.

CONTENTS

INTRODUCTION

Problem

Recent concern about fleet readiness has made the maintenance of personnel skills an important issue. Quantitative methods of assessing performance are needed to document specific skill losses. The necessary techniques are not generally available, however, and they cannot be developed and implemented except at great cost. Thus, there is a need to develop alternative procedures for identifying and estimating of skill loss problems.

Objectives

The objective of this work was to provide the background information required to help understand and identify conditions that cause skill losses. Specifically, this work sought to:

1. Review the relevant research literature and theory regarding skill losses to identify variables that produce or contribute to such losses.

2. Discuss the ways in which these variables might operate in Navy personnel management practices and in job assignments.

3. Lay the ground work for the development of procedures for identifying whether or not these variables are operating to produce skill losses.

Background

The complexities of Navy operations and recruit accession practices make it difficult to develop and to maintain the skills and job proficiency of enlisted personnel. Recent concern over fleet readiness and the level of personnel skills has raised important questions about the skill levels of Navy enlisted personnel. For example, are the aptitudes of recruits declining seriously? Is training sufficient? Can we counteract the effects of rapid turnover, with its accompanying loss of experienced personnel? How do assignment and rotation practices affect readiness and proficiency? Can we predict training and job conditions that lead to skill losses, and can we prescribe methods for maintaining skill proficiency?

Studies of skill deterioration and forgetting show that losses in proficiency are influenced by a number of variables: the level at which the skill was originally learned, the lengths of periods of nonuse, the kind of skill learned, the types of activities engaged in during nonutilization, and job conditions that fail to provide practice and/or corrective feedback for errors.

Many of these situations result from personnel management practices. For example, periods of nonutilization occur whenever personnel are assigned outside of their skill specialty, when they perform skills infrequently on the job, or when there is an interruption in their service career. Deterioration can also occur under job situations where the information about the adequacy of performance is either absent or inaccurate, so that errors cannot be corrected. Skill loss may also result from low levels of initial training that may be established because of pressures to minimize the length of formal training.

The quest for efficiency influences training philosophy. For example, since the teaching of "theory" takes considerable time and since its usefulness is doubted, it has

been eliminated from many courses. Yet, theory enables people to conceptualize and to explain phenomena and to structure their reasoning. It may also serve to enhance memory. Therefore, elimination of theory in a training program may aggravate the level and rate of skill deterioration.

Finally, job rotation practices that take personnel away from their jobs for extended time periods contribute to losses in skills.

Although these factors are known to be related to skill deterioration, direct assessment of their effects on Navy jobs is lacking. Documentation of specific skill losses and determination of likely causes for them is required before any remedial action can be taken. Job performance is usually assessed with subjective and qualitative methods that provide little information for identifying skill levels or losses. Without more precise qualitative and quantitative performance assessments, it is impossible to know when or to what degree a skill has deteriorated. It is also impossible to determine whether a preventative or corrective action has been effective.

These conditions are unlikely to change soon. Performance measurements suitable for assessing skill losses are costly and time consuming to develop, and cannot be recommended as a general practice in Navy personnel management. Therefore, other and less direct techniques are needed to examine conditions of training, of the job, and of job rotation, which will indicate whether skill deterioration on a task is likely. Then, adjustments in personnel management practices could be recommended. No techniques of this sort exist. It is likely that they would take the form of a survey questionnaire. The development of these techniques would provide useful information to personnel managers and supervisors. However, a development and validation effort is needed to generate this capability. It is the objective of this report to provide the background for this development effort.

APPROACH

The approach was to synthesize an overall picture of the factors that affect skill retention from data abstracted from the recent scientific literature. The primary data sources were five previous reviews of the literature, including two early classics (Gardlin & Sitterly, 1972; Naylor & Briggs, 1961) and the three most recent surveys (Annett, 1977; Prophet, 1976; Schendel, Shields, & Katz, 1978). Each of these major reviews attempted to search the available literature (over 620 articles were cited) and to summarize the findings. Other primary data sources included publications that represent current efforts to study skill loss.

The variables identified as being most closely related to the retention of Navy skills were grouped into the following five categories:

1. Personnel characteristics.
2. Task variables.
3. Training factors.
4. Job conditions.
5. Retraining variables.

Assignment to a category was an attempt to represent when, where, and how the variables act to affect skill retention and loss.

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During discussion of findings shared by two or more sources, references were not cited in order to avoid excessive distractions. Readers interested in pursuing a more academic and technical study of skill retention will want to refer directly to the primary sources used in this report.

FINDINGS AND DISCUSSION

Personnel Characteristics

The most important of the individual characteristics related to skill retention are ability and experience; age as a variable is less relevant.

Motivation does not seem to be important to skill retention. While it is true that a person must have a desire to learn and some interest in the topic in order to learn a new skill, the skill will not be forgotten just because the person's interest wanes. Of course, a poorly motivated person may stop performing a task, and thereby appear to lose proficiency, but this problem is not the subject of this report.

Ability

The amount of skill retained over time is directly related to the amount of initial learning. When the time available for learning is fixed, high ability personnel will learn more than will low ability personnel. Ability level, therefore, is a good predictor of skill retention in this situation.

The findings indicate that, if both high and low ability personnel are trained to the same level of proficiency, there will be no retention differences between the two groups; the actual rate of forgetting is independent of the level of ability. The major tradeoff needed to ensure that low ability personnel acquire the same retention capability as high ability personnel is to give them longer training.

Experience

A person's previous knowledge and experience can significantly influence the rate of learning a new task, the level of training obtained, and the subsequent retention of the new task. If the new learning is facilitated by past experience and learning, the effect is called positive transfer. The amount of transfer is usually related to the similarity between the new material and the old. Similarities between new and old material are thought to make new task elements more meaningful to the learner. Past learning, therefore, aids recall of newer skills.

Aging

Although a number of studies have found that aging is accompanied by slow, progressive declines in physical strength and in short-term memory, this factor has not been found to be associated with significant decreases in skill retention, nor has it been reported to have any significant effect during the period of concern to the Navy. The reason that aging does not contribute to declines in skill proficiency is probably due to an interaction with experience and knowledge factors. Over time, accrued experience tends to compensate for losses caused by aging.

Task Variables

Type of Task

The types of tasks that Navy personnel are most often required to learn and remember are the very types that are most difficult to retain. The type of task judged as most necessary and important to Navy mission readiness is the procedural task (Campbell, O'Connor, & Peterson, 1976). A sonar operator, for example, performs a procedural task when he selects the appropriate operational control settings on a piece of equipment in order to conduct a sonar search. Fire control and missile technicians perform procedural tasks when they take the actions required to prepare and fire a weapon.

The research literature clearly indicates that complex procedural skills are highly subject to deterioration, even after only short periods of nonuse. Procedural tasks consist of sequences of distinct steps, actions, or elements. They are the most difficult type task to learn and the easiest to forget. The main problem in most procedural tasks is remembering the correct step from a large group of possible steps (e.g., what control knob to turn and in what order (what to do next) rather than how to turn the knob (how to do it)).

Task Organization

Task organization is extremely important because it may be the underlying reason why different tasks appear to have different learning and forgetting rates.

The structural organization refers to the coherence of the steps and elements of the task; it is related to the logical sequencing, order, or pattern of the steps. Organizational meaningfulness refers to the familiarity and memorableness of the steps of the task; it is related to the prior knowledge and experience of the learner or performer. A person's knowledge structure influences how and what learning is done, and it later influences how and how well something is remembered. The Navy needs to attend to this concept in training programs.

Complexity

Complexity refers to the number of steps or subtasks included in the task. The general finding is that, as complexity increases, forgetting of steps or subtasks increases. Skill retention is decreased when one task step fails to signal, indicate, or logically lead to the next step in the sequence. Skill retention also decreases when a subtask is not directly related to getting the main job performed. Examples of subtasks that are often unrelated to the major function of a job are safety procedures and damage control steps. It is predictable that the steps that are most likely to be forgotten are those that are consistently the most difficult to perform correctly, require the most memory, or take the longest to learn (Shields, Goldberg, & Dressel, 1979).

An examination of Navy ratings showed that the ratings classified as hardest to learn and needing the most schooling were the same ratings in which errors were most often predicted to result in failure to carry out missions or in losses of ships, planes, and personnel (Campbell et al., 1976). These ratings almost always involve skills required to operate and to maintain complex equipment; they may also require quick, decisive interpretations of data directly related to attack and to defense against enemy submarines and aircraft. Some of these ratings are fire control technician, sonar technician, electronics warfare technician, missile technician, gunner's mate, data systems technician, air traffic controller, and aviation electronics technician.

These ratings involve performance of complex procedural tasks, tasks involving many steps and subtasks. In addition, many of these tasks lack logical organizational structure, meaningfulness, or context that would link the various steps together in such a way as to aid their recall. This means that the many of the most important jobs in the Navy are comprised of procedural tasks that are difficult to learn and easy to forget.

It has been estimated that roughly 75 percent of Navy ratings require technically skilled personnel, as compared to 30 percent for Army occupations (Taylor & Thalman, 1977).

Training Factors

The principal training factors affecting skill retention are:

1. Amount of initial learning.
2. Training methods.
3. Knowledge of results.
4. Test trials.
5. Training environment.

Amount of Initial Learning

Of all the variables related to the retention of skill over a period of nonuse, the single most important is the amount of initial learning. This means that the personnel who learn their skills best will remember them longest. An even broader generalization is that personnel who perform a skill well early in their training are likely to be better performers of that skill later on the job. Any variable that leads to high initial levels of learning, such as high ability or frequent practice, will facilitate skill retention.

Levels of initial training are influenced by Navy policies. For example, budget and time restrictions dictate the policy of minimizing training time. Formal courses are therefore designed to give the least amount of training needed to prepare people for their jobs. Job skills are seldom measured quantitatively, and training is often judged to be complete when an end-of-course examination is "passed" (i.e., when a set score on a test has been achieved), when all steps of a laboratory exercise have been performed, or when a task has been performed correctly once.

The major problem with minimizing training time in this fashion is that any decline in performance, no matter how small, will bring the skill level below an acceptable level of readiness. Since the amount of training directly determines retention, this policy almost guarantees that performance will fall below the acceptable standard during any period of nonuse.

This policy also runs counter to a recommendation from research that, to maximize learning and retention, practice should be abundant and extensive. Training carried beyond the minimal acceptable level of performance, sometimes called overlearning, is achieved by extensive practice. It is associated with high levels of skill retention, as well as other benefits.

Performance levels for some skills continue to improve across long periods of time, even years, when associated with regular practice (Chase & Chi, 1979). Radar and sonar operators, for example, might continue to increase the speed with which they identify or classify targets. They could also be expected to make fewer and fewer errors with increased experience. Experience gained through practice and familiarization with a job or task produces "expertise."

The Navy recognized that the "accrued utility" or usefulness of enlisted personnel is a function of their experience and that it is specific to their ratings or duty assignments (Campbell et al., 1976). A major benefit of having experienced personnel on the job is that they can perform most tasks in a routine manner and also attend to other, perhaps more difficult, aspects of their job at the same time.

While practice is important for initial training, for continuing improvement, and for developing higher levels of proficiency, specific methods and schedules for performing practice have not been found to affect retention levels. What is important about practice, and it will be emphasized throughout this report, is performing the actual physical and mental functions required by the task. The more closely the practice approximates the functional requirements of the task, the more effective the learning and skill retention.

In summary, the amount of initial training is directly related to the amount of retention of job skills during periods of nonuse. The degree of initial training needed in school or on-the-job to prevent skill loss problems will depend on whether job conditions provide personnel with enough practice to maintain or to improve their skill level.

Training Methods

Training methods that use memory aids can help a person to learn and retain complex procedural skills and information (Ainsworth, 1979). Examples of memory aids are mnemonic devices and contextual cues. Their effects are thought to be due to the organizing and integrating effect they introduce to task elements that might otherwise appear to be unrelated. They help to form mediating links between elements of the task. Retention of new material can be improved by learning to use familiar cues to retrieve or recall less familiar material. Among the techniques that have been used as context cues are images, keywords, stories, associations, and rhymes (Morris, 1979; Kincaid, Salas, & Braby, 1980; Sturges, Ellis, & Wulfeck, 1981). Among the strategies used to learn and remember the elements of a task are labeling, organizing, and categorizing (Ainsworth, 1979; Howe & Ceci, 1979). Technical training can include instruction in how to use these mnemonic strategies. Practice in using memory aids will contribute to increasing a person's knowledge about his or her job.

Knowledge of Results

The research literature is clear about the importance of one variable that must be present during the learning process. This variable is called knowledge of results or "feedback." It indicates to a trainee the adequacy of his or her performance. For a person to learn quickly and effectively, knowledge of results must be available to help in the recognition and correction of errors in performance. It is crucial and necessary during early learning. Its source is sometimes from the task itself (e.g., dial readings, blinking lights, sounds and noises, disappearance of signal interference, etc.), while in other

situations it is external (e.g., scores on individual parts of an exercise, supervisor's comment, collaboration from intelligence or from another ship).

Knowledge of results has been identified as being the fundamental difference between formal training and on-the-job training (Hagman & Schendel, 1979). In formal Navy technical training programs, the trainee is frequently given appraisals of successes and shortcomings. In on-the-job training, such feedback is less common. For example, supervisors may not closely monitor personel on the job, and they may not necessarily inform personnel about correctness or timeliness of their activities.

Knowledge of results is more than just information used to correct errors. It also helps the learner to observe and to use cues associated with the task. This process develops self-generated feedback (knowledge) that tells the learner how correct performance looks, feels, and sounds. Then, after learning and practicing a skill, the performer will not have to depend constantly upon external or task-related information. What is not known is how long a person will remember these feedback cues without other sources of knowledge of results.

On-the-job as well as in school, personnel must receive regular and consistent feedback if they are to maintain their performance at an acceptable level of readiness. For example, knowledge of results is needed to maintain proficiency during practice. Imagine a sonar operator who occasionally detects and classifies a signal but who seldom finds out whether it was real (e.g., a submarine or a mine) or spurious (e.g., a school of fish or a burst of noise). Under these circumstances, detection and classification actions could not be considered as substantial practice of the task. Equally important are the situations where an operator misses a signal and never learns about it.

Test Taking

Test taking facilitates both learning and retention. Like knowledge of the results of task performance, knowledge of test results helps the trainee to learn and to know where his or her learning is incomplete. The more closely the process of solving test problems approximates the process of performing the task, the more the trainee benefits from the test. Test taking may also serve as a form of "strategy practice" for learning to organize memory for recalling task elements.

Testing may offer additional benefits. For example, tests provide practice or refresher training in situations where there are few opportunities for practicing job skills. Morris (1979) has suggested that frequent self-testing improves the probability of future recall.

Training Environment and Equipment

The training devices used in schools, and the operational equipment used on the job, make up a large part of the training environment. The most important relationship between them is their functional similarity--the way they appear to act, work, and look to the trainee. The way a training device actually looks may be much less important than whether the trainee's performance when using the device is representative of the performance required by the task. For example, Grimsley (1969) found that using a drawing of some operational equipment to learn and remember a 92-step procedural task (firing a Nike-Hercules missile) produced the same learning and retention as using the actual equipment. This "representativeness" principle may also offer an explanation of why some cases of "mental practice" appear to facilitate learning and retention.

The retention and maintenance of procedural skills can be aided by proper human engineering of the operational equipment. For example, display/control relationships that are consistent with an operator's past experiences or with principles of human bio-mechanics have been shown to facilitate learning and to promote retention. Design compatibility is vital in aiding memory in dangerous or infrequently performed tasks (Shinar & Acton, 1978). Where there are inconsistencies in design, errors are likely to occur (Norman, 1981).

Operational equipment can be designed with feedback. One form of such feedback uses equipment-produced signals or displays to tell an operator about the adequacy of performance or prompt the operator on each successive step in a complex task. Whenever it is economically and practically possible, feedback systems should be designed into equipment; they can facilitate skill maintenance and also serve as the basis for embedded training.

Job Conditions

Two of the major job conditions affecting skill retention are nonutilization periods and recall.

Nonutilization Periods

The research findings show a direct relationship between the length of nonutilization periods and the amount of skill lost. The longer the time interval a skill is not practiced, the greater the skill deterioration. Task variables also interact with nonutilization and cause different skills to decline at different rates. For example, complex procedural skills with many steps and subtasks deteriorate rapidly, sometimes within hours, or days, when not practiced.

Skill deterioration caused by nonutilization may be a substantial problem in the Navy. Taylor and Thalman (1977) stated:

> The majority of Navy personnel are highly trained, and as high as 25 percent are assigned outside their skill areas and require retraining upon return to their occupational specialities.

The Navy, if it is to maintain acceptable levels of readiness, must be concerned with providing either refresher training or frequent and regular practice for complex, mission-critical, procedural tasks.

The initial step in reducing skill losses caused by nonutilization is to identify situations where personnel have few opportunities to practice or to use their job skills. Some of these situations are obvious: administrative and management delays, leave following immediately after formal school training, and assignment to auxiliary duties immediately after reporting to a duty station. As an example of the last case, sonar technicians reporting for duty following completion of "A" school are routinely assigned to perform galley (kitchen) chores for periods of at least 4 weeks.

Less obvious examples are lack of practice opportunities in everyday job performance. Some equipment is so reliable that technicians are seldom required to trouble-shoot or repair it (Laabs, Pannell, & Pickering, 1977). When such equipment does fail, as it inevitably will, there may not be anyone aboard ship with enough experience to repair it quickly. Radar and sonar contacts occur infrequently during routine watches, and

operators may have had little experience in classifying contacts despite having spent hundreds of hours at a console.

Another example is the situation that looks like practice but which produces skill deterioration. This happens whenever the task being practiced is performed incorrectly and when feedback to the performer is either absent, inadequate, or erroneous.

Recall

The recall of learned skills can be adversely affected by a wide variety of environmental, contextual, physiological, or psychological conditions.

Environmental Conditions. Extremes in environmental conditions, such as high noise levels and long exposures to heat, have been reported to damage recall (Jones, 1979).

Contextual Differences. Recall is affected by the degree of similarity between the recall situation and the original learning conditions. As Annett (1977) has pointed out: " in real life, even with physically identical conditions, the retention or relearning situation could be subjectively different." In other words, day-to-day work conditions may be psychologically different enough from the original learning conditions to degrade performance.

Physiological Stress. Physiological states, such as fatigue, can influence physical strength and coordination; they can also interfere with memory and attention.

Psychological States. One of the most important causes of disruptions of memory, with its attendant impairment of performance, is psychological stress. This type of stress is easily induced by emergencies, whether or not they are life threatening. Performance of corrective actions or escape procedures frequently deteriorates under psychological stress. This type of behavioral breakdown occurred during the nuclear power plant accident at Three Mile Island, where plant operators made a number of procedural errors after alarm and warning signals began to indicate the existence of an emergency condition.

Retraining

Retraining is a procedure for refreshing, relearning, or maintaining skill levels. Since many retraining methods are available, the selection of cost-effective alternatives should be easy. In addition to reestablishing skill levels, retraining enhances performance because it increases experience (Prophet, 1976). Retraining may also improve on-the-job safety and performance (Schendel et al., 1978). It can be used to reduce memory load (Jones, 1979). Lastly, retraining can be used to learn new skills, even on tasks performed routinely on the job (Hagman & Schendel, 1979).

The utilization of retraining depends upon knowing where, when, and how much to use. The three most important considerations are the conditions, methods, and time requirements.

Conditions Needed for Retraining

Retraining is a function of the same conditions that influence initial training. The more closely the retraining resembles the initial training, the better the skill retention. Retraining, like initial training, must stress those job elements that will determine the success or failure of the job.

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Determining the presence or absence of conditions that are important to maintaining job skills is an integral part of any program designed to identify skill retention problems. Knowing these conditions is also necessary to be able to prescribe and develop remedial or retraining schemes for preventing or counteracting skill loss. Knowledge of results helps to shorten retraining time; that is, the effectiveness of a retraining procedure will depend upon the availablity of cues about the results of performance that are given to a trainee (Schendel et al., 1978).

Methods Used for Retraining

Methods commonly used in initial training are effective for retraining. Previously learned procedural skills can be rapidly reactivated by studying appropriate job-performance aids or self-study materials. Study guides can be used to enrich job procedures that are seldom or never practiced (Laabs et al., 1977).

Symbolic rehearsal of the criterion task, using photographs of an instrument panel, has also been used to keep skill levels relatively high (Annett, 1977). Studying technical manuals can refresh skill memory and reduce the need for refresher training (Shields, Joyce, & Van Wert, 1979). Test taking can prove beneficial as a refresher training technique and reduce the overall refresher training time (Schendel et al., 1978), and performance testing may be a promising way to maintain task proficiency (Arima & Neil, 1978).

A common denominator of all retraining methods seems to be that of providing opportunities for practicing job skills.

Time Required for Retraining

The general findings from the literature emphasize that, in comparison with initial training, retraining can be accomplished quite readily. Maintenance of previously acquired skills appears to require only occasional practice and short periods of rehearsal. This implies that personnel who practice their skills will continue to remember and perform them better than will personnel who do not practice. Even short periods of practice can keep skills at relatively high levels, and practice of only one aspect of a task seems to be helpful in maintaining performance.

Whatever method is used, the amount of retraining needed to reinstate skill performance to an acceptable level appears to be inversely related to the length of the nonutilization period. Well-learned skills are relearned more rapidly than poorly-learned skills. Compared to low ability learners, high ability learners require shorter and less frequent refresher training (Schendel et al., 1978).

CONCLUSIONS

Unfortunately, the scientific literature provides little information that has direct application to the problem of skill deterioration in the Navy. This is because the models upon which most of the research designs have been based are not commonly found in real jobs, and they differ dramatically from the working and learning conditions of complex working situations, e.g., the career history of Navy personnel.

Most of the reported findings in the literature investigating skill loss caused by nonutilization are the results of using simple experimental tasks and manipulating highly controlled conditions. The most common experimental design involves a well defined

period of initial learning followed by an equally well defined nonutilization period, and ends with a test of recall to measure the amount of forgetting. The findings have shown that the amount of learning prior to the period of nonuse is a prime factor in skill retention; that how well the task is learned is influenced by the background, experience, and knowledge of the learner; and that learning and retention are also affected by the type of task and the amount of practice and feedback given. This has made skill retention appear to depend upon a relatively limited set of easily understood variables.

In the Navy, though, skill loss is complicated and difficult to understand. For one thing, Navy job skills are not learned all at one time: Some skills develop out of the learner's previous background, experience, and knowledge; some are learned formally in school(s); some are learned during on-the-job training; and some are developed over time through job experience. Furthermore, Navy job conditions seldom involve a single period of nonuse that controls forgetting. Instead, there are many periods of time when personnel have no opportunity to practice certain job skills, and these intervals may act independently or collectively with previous nonutilization intervals to influence skill degradation.

There are also periods of time when skills deteriorate even though they are being practiced. This happens when performance feedback is absent, inadequate, or erroneous. Under these conditions, personnel receive credit for time on the job and are presumed to be maintaining or improving their job skills when in fact their skills are deteriorating. This type of skill loss problem may go undetected because task performance in the Navy is seldom assessed quantitatively in a way that would identify specific skill and task deficiencies on an individual basis. For example, a fleet exercise may result in evaluation of ᵔ sonar team's performance, but it will say nothing about the target classification skills o the particular sonar technician who was operating the broadband passive sonar unit during such-and-such hours.

A big problem for the Navy is the identification of skill deterioration. Identifying existing or potential skill losses is necessary in order to be able to take remedial action.

The most direct way to identify skill deterioration is through the use of performance evaluation tests (Arima & Neil, 1978). Unfortunately, job requirements and qualified standards of performance have to be agreed upon first. To develop a test that truly reflects the demands of an incumbent's job is difficult, even for a single rating (Laabs & Panell, 1976). Besides test validation problems, the implementation would be difficult, too, because criterion-referenced performance testing requires sampling hands-on skills. Additionally, the development and validation process meets with problems because of the necessity of intruding upon the duties of people at work. Finally, the cost of developing tests and establishing testing facilities would be excessive, if not prohibitive.

RECOMMENDATION FOR FURTHER DEVELOPMENT

Although research is needed to further explore factors that may cause or prevent skill losses in the Navy, it is more important to make available methods that exploit what is already known. A direct approach for identifying skill losses is not feasible for many Navy tasks, however, because of the costs and time involved in accomplishing such development. Therefore, indirect methods are recommended. One method would involve developing descriptive procedures to be used to identify conditions known to be likely to produce skill deterioration. This approach could then serve as a basis for recommending management actions that would minimize such losses.

These proposed descriptive procedures would use questionnaires, structured interviews, or checklists to survey specific ratings and to obtain information about factors that are known to be associated with skill retention or loss. Examples of the specific information to be gathered would include determining critical tasks and how well they are trained. Information about activities while on the job would include determining the kinds, types, and frequency of practice of specific skills and the sources, quantity, and quality of associated feedback. Information about periods of nonutilization would include assessing the number and intervals of "breaks" in opportunities to practice or perform job skills during duty assignment and during a service career. The basic assumption underlying this approach is that whenever and wherever these conditions are identified, there will be a high probability of finding an accompanying loss in skill performance levels. At the same time, this information will aid in pointing out changes and modifications in the job conditions or in recommending retraining to remedy the problem.

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